Progress in Pediatrics

Even the inventor of the "Apgar Score" disclaims for it a high predictive value in individual infants. But wouldn't you want your own baby born in a delivery room where the concern of the "team" for the welfare of babies was reflected in its constant use?

Further Observations on the Newborn Scoring System

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The need for a simple method whereby the newborn's condition could be rapidly evaluated was the main reason for developing a scoring system. Breathing and crying times were not satisfactory criteria, many quite severely depressed infants being treated with nothing but watchful waiting, while others who were comparatively healthy received unnecessary oxygen and manipulation.

After a 3-year period of preparatory observations at the Sloane Hospital for Women, the scoring system was first introduced in 1952.[1] it is based on 5 objective signs: heart rate, respiratory effort, muscle tone, reflex irritability, and color, judged 60 seconds after delivery. This particular time interval was chosen since, on the average, it coincided with maximal depression in our clinic.

The present paper summarizes our experience of 8 years between 1952 and 1960 and considers some other applications of the system.

Predictive Value for Survival of Premature and Full-Term Infants.—It was noted previously that the deaths of both full-term and premature infants were inversely related to score, although the "distribution" of scores of premature infants was lower than in the full-term group. Since the group

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TABLE 1.—*Mortality by Weight in 32,962 Infants*

	Total	No. Stillbirths	% Stillbirths	No. Live Births	No. Neonatal Deaths	% Neonatal Deaths
501-1,000	250	94	37.6	156	127	81.4
1,001-1,500	320	77	24.1	243	114	46.9
1,501-2,000	563	63	11.2	500	86	17.2
2,001-2,500	2,123	58	2.7	2,065	78	3.8
Over 2,500	29,706	159	0.5	29,547	135	0.5
Total	32,962	451	1.4	32,511	540	1.7

labeled "premature" includes individuals of such wide disparity in development, it was thought best to divide them into 500 gm. weight groups and examine their scores in relation to neonatal deaths. Numbers of infants were insufficient to divide them into 250 gm. weight groups.

During this 8-year period 32,962 infants were born (Table 1). Stillbirths amounted to 14 per 1,000 of which 65% were below 2,500 gm. in weight. Of the remaining 32,511 live births, 540, or 17 per thousand, died in the Babies Hospital before the 28th day of life, 75% of those dying being premature by birth weight. We have no reliable measure of the infants who may have died at home or in other hospitals. It may be noted that the number of infants weighing between 2,000 and 2,500 gm. is over 4 times that of the preceding group. Since these heavier premature infants behave more like full-term infants, both as regards mortality and morbidity, their inclusion with more immature infants (2,000 gm.), particularly if the

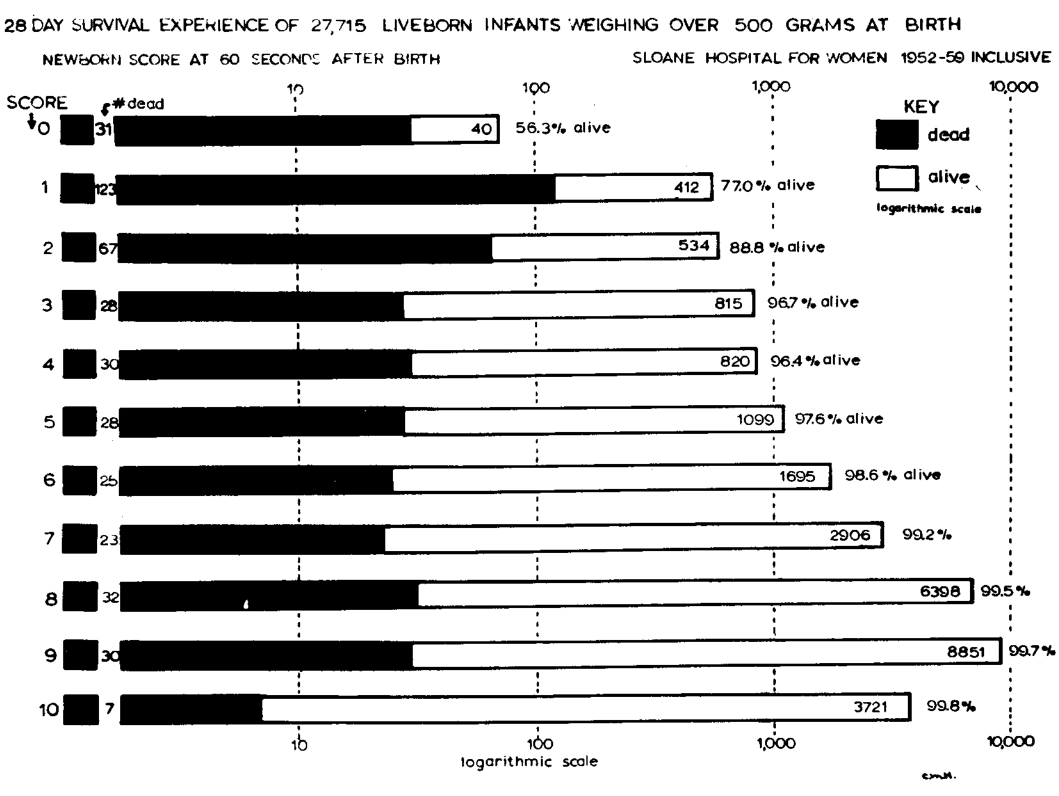

Fig. 1.—Twenty-eight-day experience of 27,715 live-born infants weighing over 500 gm. at birth.

total number being examined is small, may obscure important differences between the 2 groups. The death rate of infants below 2,500 gm. in this series is similar to that reported by Bishop from the Pennsylvania Hospital[2] in 1,272 premature infants.

A newborn score was recorded in 27,715 infants, or 85.2% of the live births. The distribution of scores and deaths is shown in Figure 1 and agrees with our earlier published observations.[3,4]

Table 2 shows that within the five weight groups there is no statistical difference in the deaths of infants who received a score and those who did not. When considered as 2 groups (scored and unscored), irrespective of birth weight, mortality did appear to be significantly higher in the unscored infants. However, because of the great difference in the per cent scored in each weight group (62% of those between 500 and 1,000 gm. and 86% of full-term infants) an over-all comparison is not valid.[5]

In Figure 2, the various contributions of prematurity to scores and deaths are illustrated. In the smallest infants (501-1,000 gm.) mortality is high at all scores. By comparison, mortality is low in full-term infants scoring 0-3. Nevertheless, in the upper 4 weight groups there is a highly significant difference in survival between infants whose score was poor (0-3), fair (4-6), and good (7-10) (Table 3). Originally, these categories from clinical observation were grouped slightly differently, (0-2), (3-7), and (8-10); but infants scoring 3 were added to the "poor" group and 7 to the "good" group as a result of biochemical studies.[6,7] In infants under 1,000 gm., scoring appeared to be of little prognostic value for survival. However, if the groups of infants too small to be included in a χ^2-test are removed (5 or less), the results are significant at the 1% level even in these very premature infants.

TABLE 2.—*Mortality in Scored and Unscored Infants*

	Dead	Alive	χ^2	P
501-1,000 gm.				
97 scored	80	17		
59 not scored	47	12	0.1759	>0.70
1,001-1,500 gm.				
192 scored	90	102		
51 not scored	24	27	0.0000	1.0
1,501-2,000 gm.				
409 scored	71	338		
91 not scored	15	76	0.0930	>0.75
2,001-2,500 gm.				
1,724 scored	70	1,654		
341 not scored	8	333	3.0433	>0.05
Over 2,500 gm.				
25,293 scored	113	25,180		
4,254 not scored	22	4,232	0.5538	>0.40

Statistical comparison of mortality between scored and unscored infants to determine whether there was any systematic difference in the 2 groups. The "P" values for the χ^2-test indicate that in this clinic there is no difference.

A marked difference in survival of infants in relation to their route of delivery may be seen in Table 4. Breech deliveries per vaginum were accompanied by the highest mortality, cesarean sections the next highest, and vertex deliveries the lowest. Prematurity played an important role in the breech delivery group, 90% of the deaths being in infants under 2,500 gm.

Experience in Other Centers.—The scoring system has been used for a number of years in both Winnipeg and Helsinki,[8] with published data correlating mortality with score showing close agreement with our own. Similar figures have been recently reported from the Boston Lying-In Hospital,[9] mortality in 3 groups classed as excellent (Score 8-10), moderately depressed (Score 3-7), and severely depressed (Score 0-2) being significantly different.

The over-all distribution of scores in liveborn infants in the Boston series was considerably different from our own, 44% of 829 live births being classed as excellent compared with 69% of 27,715 in the present series. The higher incidence of low-score infants was accompanied by a significantly higher mortality ($P<0.001$). However, mortality rates are similar if the infants of diabetic mothers are excluded. It may be noted that the 2 studies are still not strictly comparable, since the proportion of infants less than 2,500 gm. is smaller in the Boston series (5.8% compared to 8.7%).

The higher incidence of low-score infants was also paralleled by an unusually high incidence of meconium at birth, 16% in

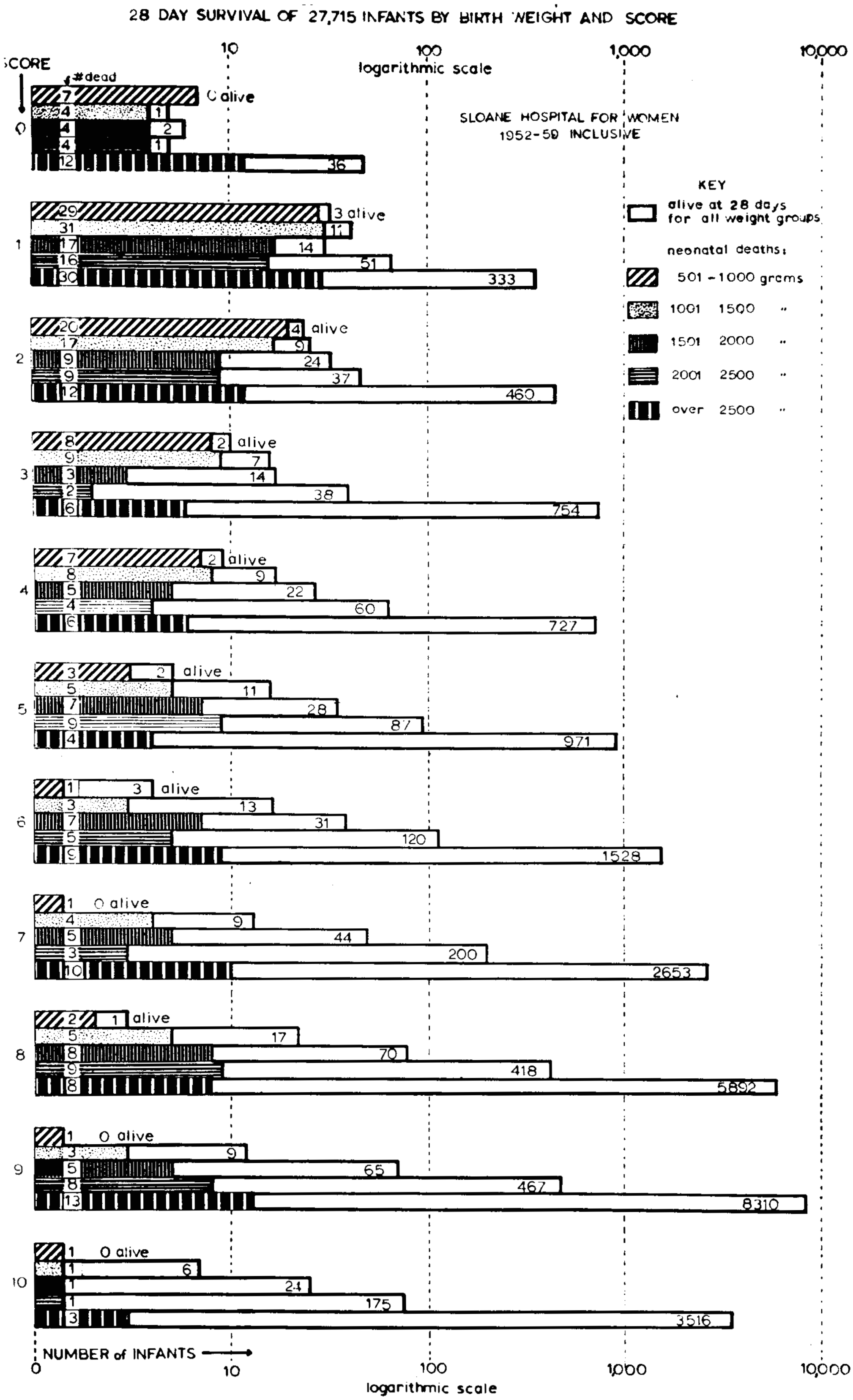

Fig. 2.—Twenty-eight-day survival of 27,715 infants by birth weight and score.

TABLE 3.—*Significance of Score and Survival in Each of 5 Weight Groups*

	Total No.	Dead	Alive	χ^2	*P*
501-1,000	97	80	17	5.1	$P > 0.05$
Poor (0-3)	73	64	9		
Fair (4-6)	18	11	7		
Good (7-10)	6	5	1		
		Omitting Groups of 5 Infants or Less			
501-1,000	91	75	16	7.9	<0.01
Poor	73	64	9		
Fair	18	11	7		
1,001-1,500	192	90	102	32.8	<0.001
Poor	89	61	28		
Fair	49	16	33		
Good	54	13	41		
1,501-2,000	409	71	338	37.7	<0.001
Poor	87	33	54		
Fair	100	19	81		
Good	222	19	203		
2,001-2,500	1,724	70	1,654	118.4	<0.0001
Poor	158	31	127		
Fair	285	18	267		
Good	1,281	21	1,260		
Over 2,500	25,293	113	25,180	476.9	<0.0001
Poor	1,643	60	1,583		
Fair	3,245	19	3,226		
Good	20,405	34	20,371		

infants with good scores and 23% in the low-score group. There was no statement regarding mortality or changes in the fetal heart rate in relation to the passage of meconium in this study. The over-all incidence of meconium reported by Fenton and Steer from this clinic [10] and by Desmond [11] is considerably lower (8%-10%). Mortality was 3 times as high as when no meconium was present in the study of Fenton and Steer. This mortality occurred only in those infants who had bradycardia together with meconium.

These differences are interesting, and at present there is no ready explanation for them. Several possibilities which might be considered include frequency or quality of observation, more serious condition of

TABLE 4.—*Mortality by Score and Route of Delivery*

	Vertex		Cesarean		Breech		Total	
Score	No. Born	No. Died	No. Born	No. Died	No. Born	No. Died	No. Born	No. Died
				501-1,000 Gm., 1952-1959				
0	2	2	2	2	3	3	7	7
1	12	10	3	3	17	16	32	29
2	15	12	0	0	9	8	24	20
3	8	7	0	0	2	1	10	8
4	8	6	0	0	1	1	9	7
5	2	0	0	0	3	3	5	3
6	3	1	1	0	0	0	4	1
7	1	1	0	0	0	0	1	1
8	3	2	0	0	0	0	3	2
9	0	0	1	1	0	0	1	1
10	0	0	1	1	0	0	1	1
Total Scored	54	41	8	7	35	32	97	80
Total not scored	39	29	0	0	20	18	59	47
Grand total	93	70	8	7	55	50	156	127

(Table 4.—Continued on next page)

TABLE 4.—*Mortality by Score and Route of Delivery*—Continued

Score	Vertex No. Born	Vertex No. Died	Cesarean No. Born	Cesarean No. Died	Breech No. Born	Breech No. Died	Total No. Born	Total No. Died
				1,001-1,500 Gm., 1952-1959				
0	3	3	1	1	1	0	5	4
1	21	14	9	5	12	12	42	31
2	11	7	2	1	13	9	26	17
3	5	3	4	2	7	4	16	9
4	9	4	1	1	7	3	17	8
5	8	3	3	1	5	1	16	5
6	10	2	2	0	4	1	16	3
7	7	2	2	2	4	0	13	4
8	16	4	2	0	4	1	22	5
9	9	2	2	1	1	0	12	3
10	4	0	3	1	0	0	7	1
Total scored	103	44	31	15	58	31	192	90
Total not scored	42	18	1	1	8	5	51	24
Grand total	145	62	32	16	66	36	243	114
				1,501-2,000 Gm., 1952-1959				
0	2	1	3	2	1	1	6	4
1	12	8	7	4	12	5	31	17
2	18	4	6	1	9	4	33	9
3	11	1	1	0	5	2	17	3
4	18	3	4	1	5	1	27	5
5	21	5	4	1	10	1	35	7
6	27	5	8	2	3	0	38	7
7	37	4	7	1	5	0	49	5
8	61	4	9	2	8	2	78	8
9	65	4	3	1	2	0	70	5
10	22	1	3	0	0	0	25	1
Total scored	294	40	55	15	60	16	409	71
Total not scored	76	11	5	1	10	3	91	15
Grand total	370	51	60	16	70	19	500	86
				2,001-2,500 Gm., 1952-1959				
0	4	3	0	0	1	1	5	4
1	41	10	16	5	10	1	67	16
2	29	5	5	1	12	3	46	9
3	30	2	5	0	5	0	40	2
4	45	3	12	1	7	0	64	4
5	68	8	7	1	21	0	96	9
6	85	1	19	3	21	1	125	5
7	149	2	31	1	23	0	203	3
8	361	6	45	3	21	0	427	9
9	433	7	27	1	15	0	475	8
10	167	1	9	0	0	0	176	1
Total scored	1,412	48	176	16	136	6	1,724	70
Total not scored	304	7	15	1	22	0	341	8
Grand total	1,716	55	191	17	158	6	2,065	78
				Over 2,500 Gm., 1952-1959				
0	36	12	8	0	4	0	48	12
1	243	17	87	11	33	2	363	30
2	368	10	71	1	33	1	472	12
3	664	5	64	1	32	0	760	6
4	602	4	76	2	55	0	733	6
5	844	3	84	0	47	1	975	4
6	1,327	8	127	0	83	1	1,537	9
7	2,319	9	258	1	86	0	2,663	10
8	5,136	7	630	1	134	0	5,900	8
9	7,528	12	701	1	94	0	8,323	13
10	3,277	2	222	1	20	0	3,519	3
Total scored	22,344	89	2,328	19	621	5	25,293	113
Total not scored	4,122	19	67	1	65	2	4,254	22
Grand total	26,466	108	2,395	20	686	7	29,547	135

TABLE 5.—*Survival of Erythroblastotic Infants*

	Total Born Alive	NND*	% Deaths
Poor (0-2)	19	10	52.6
Fair (3-8)	99	7	7.1
Good (9-10)	109	4	3.7
	227	21	9.3

$P < 0.001$ with or without "good" group. (Score 8 is included in "fair" group. Figures for individual scores not available.)
* NND indicates neonatal death.

TABLE 6.—*Survival of Infants Born of Diabetic Mothers*

Score	Total Born Alive	NND	% Deaths
0	0	0	15.4
1	4	2	
2	9	0	
3	8	1	6.8
4	4	1	
5	4	0	
6	13	0	
7	15	1	
8	27	0	3.2
9	28	1	
10	7	1	
Total	119	7	5.8

mothers admitted to Boston Lying-In Hospital, or differences in the use of analgesic and anesthetic drugs.

Erythroblastosis and Diabetes.—Tables 5 and 6 list score and mortality in 227 infants with Rh incompatibility and 119 infants of diabetic mothers born at Sloane Hospital for Women.[12] Although mortality is high in both of these conditions, a similar relationship between score and survival may be seen.

In infants of diabetic mothers a slightly different distribution of scores was recently reported by Auld et al.[9] with a rather higher mortality (14.4%). Without a knowledge of the severity of maternal diabetes, number of infants delivered by cesarean section, or premature induction, it is not possible to account for the differences in these 2 series.

Clinical Correlation.—Desmond and coworkers have correlated the score at one minute with the clinical behavior of the infant over the first few hours of life.[13,14] Her earlier description of "transitional distress"[15] divides the development of various clinical signs into 3 phases which parallel the symptomatology of patients recovering from an asphyxial episode. Transitional distress has been observed in both higher- and lower-scored groups, but occurred with greater frequency and persisted over a longer period in the more depressed infants.[16]

Due primarily to inadequate records it has been assumed for many years that infants developing respiratory distress were normal at birth. With carefully documented observations it has now become evident that such is not usually the case. In our experience with 308 premature infants weighing less than 2,000 gm. at birth, nursery observations revealed retractions accompanied in many instances by grunting in 88% of 86 infants scoring 3 or less, but in only 37% of 138 infants scoring 7 or higher. Further, of 94 infants who died and had hyaline membranes at autopsy, over half were in the low-score group, scoring 3 or less, and three-fourths scored 6 or less.[17]

Value of the Scoring System in Neonatal Research.—A remarkable yet characteristic feature of the newborn during the first hours or days of life is the wide range of variation in many of the physiological measurements, unaccompanied by notable clinical signs. Because the infants have appeared similar on superficial examinations, it has been tacitly assumed that this wide range occurs in a random fashion and is therefore normal. More recently attention has been directed towards the failure of various homeostatic mechanisms, either due to immaturity or occurring as a result of a complicated labor and delivery.

By quantitating the infant's condition at birth and relating these measurements to it, we have been able to subdivide our data into broad groups which, though overlapping to some extent, have proved to be significantly different. This has been true in our studies of acid-base status,[6,7,18] fetal electrocardiograms,[19] cardiac silhouette, cardiac murmurs,[20] and venous pressure.[21,22] Without the rapid method of evaluation provided by the scoring system immediately after birth when the clinical condition is changing rapidly, these relationships would have been overlooked.

Selection of Infants for Resuscitation.—The method has been found to be a valuable guide both in teaching and in clinical practice in deciding which infants to resuscitate. By its use delivery room personnel learn to observe several physical signs at once, evaluate them rapidly, and act accordingly.

Biochemical studies have revealed that infants scoring 3 or less are, by and large, severely asphyxiated.[6,7] They have further indicated the rapidity with which marked derangements in acid-base balance take place during prolonged apnea or ineffectual gasping respiratory efforts.

Although the biochemical changes which occur with asphyxia initially may stimulate the respiratory center by means of the chemoreceptors, more profound changes appear to depress the center. Nevertheless, under these circumstances occasional gasps do sometimes occur, presumably because stimuli from the chemoreceptors, which continue to function under grossly deranged physiological conditions, break through the central depression from time to time. Due to these "dying" gasps, which indeed are life saving, there is a body of opinion which maintains that artificial lung expansion in such asphyxiated infants is not necessary. A carefully controlled study might prove this point, depressed infants being selected for resuscitation on a random basis. Such a study would in our opinion be highly undesirable because of the risks involved. Animal studies, where the fetuses can be subjected to controlled periods of asphyxia would be preferable and should provide adequate objective information.

In this clinic we have favored early resuscitation including artificial lung expansion, preferably within the first minute if the infant is severely depressed, rather than waiting to see whether or not the infant is capable of responding. Undoubtedly some infants receive needless assistance.

Long-Term Mental Development

Theoretically, the newborn scoring system of infants should afford a basis of comparison for future mental and musculoskeletal development. It is hoped that the use of this system by the 15 hospitals cooperating in the Collaborative Study of Neurological Deficiency will, in time, disclose whether the physical state shortly after birth bears a relationship to future development.

Four prospective studies of condition at birth and future development have been reported. Methods other than the Apgar Score were used to evaluate the infants. Graham et al., using a detailed recording system for perinatal distress, have shown a diminished mental capacity during childhood in those children who suffered appreciably difficult deliveries.[23,24]

Schachter and Apgar have retested a group of 165 children with carefully documented deliveries, 8 years after birth in 1947-1948. The scoring system had not yet been devised. The children were divided into "complicated" and "not complicated" deliveries by several means, chiefly by records of birth and resuscitation, kept by one technician during the delivery years, and full blood oxygen content analyses, 3.8 times for each infant during the first hour after birth. The children with complicated deliveries, who had been depressed at birth, had a significantly poorer performance on 4 major psychological tests.[25]

Prechtl and Dijkstra[26] performed neurological examinations at 48 hours and 2-4 years on full-term infants in whom there had been evidence of fetal distress or whose mothers had suffered complications of pregnancy and labor. Of the group revealing neurological abnormalities at 48 hours, 68% were abnormal at 2-4 years, while only 8% of a normal control group were so afflicted.

Studies of Bailey and Windle[27] on newborn guinea pigs asphyxiated at birth have cast considerable doubt on the thesis that short asphyxial episodes are harmless. Preliminary studies on asphyxiated newborn monkeys show similar results.[28]

Conclusion

A chart comparing mortality and score as in Figure 1 can readily be constructed for any obstetrical service and can serve as a useful baseline for improvement and for comparison with results from other clinics. Differences in mortality may provide important leads for future investigation.

While we believe the score is useful, it has many limitations. It is no substitute for a careful physical examination or serial observations over the first few hours of life. Nor will it predict neonatal death or survival in individual infants. Indeed, few signs in medicine give that definitive an answer. This objection in no way detracts from the value in estimating the probability of survival or death in groups of infants.

We would like to express our appreciation to Miss Cornelia Berrien for her help in collecting the data.

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EDITOR'S COMMENT: "On old Olympus' Towering Top" helped us get through anatomy. Possessed of an uncertain memory, we've used mnemonics occasionally ever since to help us remember something long enough to start using it. We're not sure Dr. Apgar would approve, but the following scheme from Colorado may help some budding neonatologists start using her scoring system. By our dictionaries, this is an acronym rather than an epigram, but that shouldn't detract from its usefulness.

Epigram of the Apgar Score

		Score		
	Sign	0	1	2
A	Appearance (color)	Blue pale	Body pink Extremities blue	Completely pink
P	Pulse (heart rate)	Absent	Below 100	Over 100
G	Grimace (reflex irritability response to stimulation of sole of foot)	No response	Grimace	Cry
A	Activity (muscle tone)	Limp	Some flexion of extremities	Active motion
R	Respiration (respiratory effort)	Absent	Slow Irregular	Good strong cry

Sixty seconds after complete birth of infant (disregarding cord and placenta), the 5 objective signs are evaluated and each given a score of 0, 1, or 2. Score of 10 indicates an infant in best possible condition.

Table from:
Butterfield, J., and Covey, M. J.
PRACTICAL EPIGRAM OF THE APGAR SCORE
Letters to the Journal, J.A.M.A.
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